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LaGrange County, Indiana

Pacific Northwest Environmental Res. Lab.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

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CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

P.O. 699-440

REPORT

ON

DALLAS LAKE

LAGRANGE COUNTY

INDIANA

EPA REGION V

WORKING PAPER No. 326

WITH THE COOPERATION OF THE

INDIANA STATE BOARD OF HEALTH

AND THE

INDIANA NATIONAL GUARD

MARCH, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an \dministration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange

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Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

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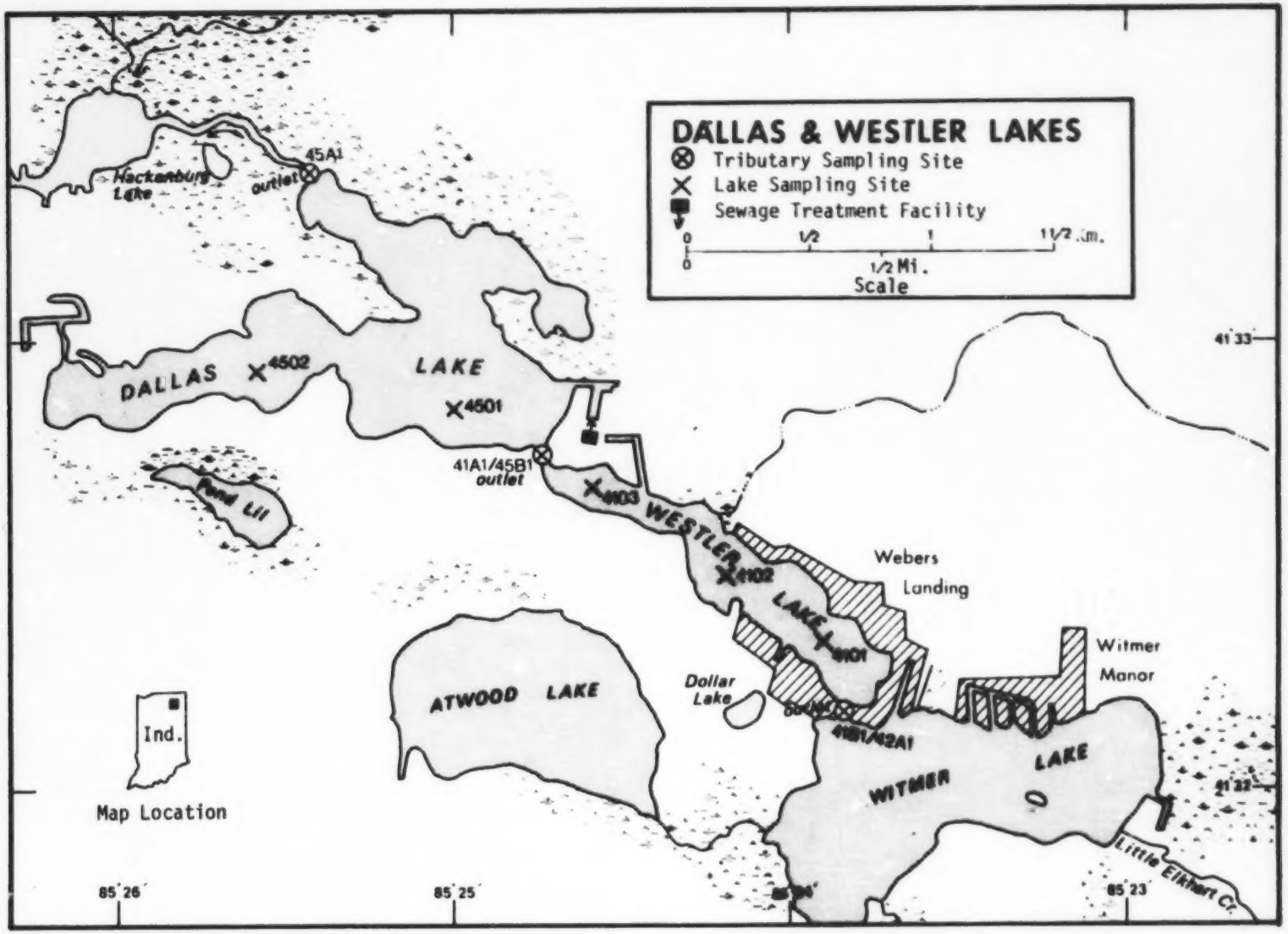
DALLAS & WESTLER LAKES
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1/2 1 1 1/2 Km.
0 1/2 Mi.
Scale
Hackenburg Lake
45A1
outlet
DALLAS
4502
LAKE
4501
41A1/45B1
outlet
Pond Lil
4503
WESTLER
4102
LAKE
4101
Webers
Landing
Witmer
Manor
ATWOOD LAKE
Dollar
Lake
41B1/42A1
WITMER
LAKE
Little Elkhart Cr.
Ind.
Map Location
41°33'
41°32'
85°26'
85°25'
85°24'
85°23'

DALLAS LAKE

STORET NO. 1845

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Dallas Lake is eutrophic. Of the 27 lakes sampled in Indiana in 1973, Dallas Lake ranked tenth in overall trophic quality using a combination of six parameters*. Ten of the lakes had less median total phosphorus, 18 had less median dissolved phosphorus, 11 had less median inorganic nitrogen, eight had less mean chlorophyll a, and eight had greater mean Secchi disc transparency. Near-depletion or depletion of dissolved oxygen occurred in the hypolimnion at both stations in August and October.

Survey limnologists noted light algal blooms and emergent and submerged macrophytes.

B. Rate-Limiting Nutrient:

The algal assay results show that Dallas Lake was phosphorus limited at the time the assay sample was collected (05/04/73). The lake data indicate phosphorus limitation in August as well but nitrogen limitation in October.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Dallas Lake received a total phosphorus loading just over 1½ times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading. The

* See Appendix A.

only known direct point source, Whetzel High School, is estimated to have contributed 16.4% of the total phosphorus load.

An indirect point source, the Village of Wolcottville, impacts upstream Witmer Lake; and, considering the relatively small phosphorus retention in the intervening water bodies (less than 33% in Witmer Lake and less than 12% in Westler Lake), this source probably impacts Dallas Lake as well.

While even complete removal of phosphorus at the Whetzel High School treatment plant would still leave a loading of about 1.3 $g/m^2/yr$ (0.3 $g/m^2/yr$ in excess of the eutrophic loading), if a high degree of phosphorus removal is provided at the High School plant and at the Wolcottville plant, it is likely to result in persistent phosphorus limitation in Dallas Lake (see page 7) and a reduction in the incidence and severity of nuisance algal blooms.

2. Non-point sources--During the sampling year, the non-point phosphorus contributions of the Westler Lake outlet and the immediate drainage accounted for nearly 82% of the total phosphorus load to Dallas Lake.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 1.14 kilometers^2.
2. Mean depth: 10.8 meters.
3. Maximum depth: 29.3 meters.
4. Volume: 12.303 x 10^6 m^3.
5. Mean hydraulic retention time: 148 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Westler Lake outlet	97.9	0.92
Minor tributaries & immediate drainage -	4.1	0.04
Totals	102.0	0.96

2. Outlet -

Dallas Lake outlet	103.1**	0.96

C. Precipitation***:

1. Year of sampling: 111.6 centimeters.
2. Mean annual: 91.3 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Dallas Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 28.6 meters at station 1 and 21.3 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR DALLAS LAKE
STORET CODE 1845

	1ST SAMPLING (5/ 4/73)			2ND SAMPLING (8/ 3/73)			3RD SAMPLING (10/12/73)		
	2 SITES			2 SITES			2 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	8.8 - 12.4	10.3	10.5	7.9 - 25.8	14.9	11.5	6.3 - 19.4	12.1	9.8
DISS OXY (MG/L)	3.4 - 10.1	7.9	8.3	0.0 - 8.5	2.6	0.1	0.0 - 8.8	2.6	0.0
CNDCTVY (MCROMO)	450. - 520.	487.	490.	324. - 450.	378.	356.	327. - 395.	364.	357.
PH (STAND UNITS)	7.4 - 8.5	8.1	8.1	7.3 - 8.5	7.9	7.5	7.3 - 8.5	7.7	7.5
TOT ALK (MG/L)	195. - 199.	197.	197.	177. - 240.	194.	195.	177. - 220.	196.	200.
TOT P (MG/L)	0.023 - 0.142	0.048	0.036	0.014 - 0.282	0.061	0.023	0.017 - 0.360	0.097	0.028
ORTHO P (MG/L)	0.002 - 0.103	0.020	0.006	0.005 - 0.181	0.038	0.012	0.010 - 0.324	0.089	0.020
NO2+NO3 (MG/L)	0.770 - 1.040	0.882	0.870	0.060 - 1.080	0.389	0.170	0.010 - 0.330	0.052	0.035
AMMONIA (MG/L)	0.030 - 0.240	0.054	0.040	0.060 - 1.440	0.292	0.170	0.030 - 2.610	0.769	0.435
KJEL N (MG/L)	0.500 - 1.180	0.780	0.780	0.880 - 2.080	1.123	0.900	0.700 - 3.480	1.575	1.150
INORG N (MG/L)	0.810 - 1.140	0.935	0.900	0.120 - 1.570	0.682	0.710	0.050 - 2.650	0.821	0.530
TOTAL N (MG/L)	1.480 - 2.040	1.582	1.490	0.860 - 2.130	1.432	1.460	0.710 - 3.460	1.627	1.235
CHLRPYL A (UG/L)	11.9 - 12.9	12.4	12.4	8.3 - 13.2	10.7	10.7	5.8 - 8.3	7.0	7.0
SECCHI (METERS)	2.4 - 2.7	2.6	2.6	1.5 - 1.8	1.7	1.7	2.1 - 2.6	2.4	2.4

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/04/73	1. Fragilaria sp.	824
	2. Oscillatoria sp.	706
	3. Asterionella sp.	426
	4. Melosira sp.	324
	5. Dinobryon sp.	177
	Other genera	367
	Total	2,824
08/03/73	1. Aphanizomenon sp.	551
	2. Dictyosphaerium sp.	357
	3. Oscillatoria sp.	298
	4. Microcystis sp.	238
	5. Lyngbya sp.	193
	Other genera	714
	Total	2,351
10/12/73	1. Aphanizomenon sp.	485
	2. Flagellates	414
	3. Cryptomonas sp.	100
	4. Dinobryon sp.	100
	5. Chlamydomonas sp.	100
	Other genera	298
	Total	1,497

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/04/73	1	11.9
	2	12.9
08/03/73	1	13.2
	2	8.3
10/12/73	1	5.8
	2	8.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.020	1.055	3.7
0.050 P	0.070	1.055	15.5
0.050 P + 1.0 N	0.070	2.055	14.9
1.0 N	0.020	2.055	4.2

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Dallas Lake was moderately high at the time the assay sample was collected (05/04/73). The results also indicate phosphorus limitation at that time. Note the four-fold increase in yield with the addition of orthophosphorus alone and the lack of a significant increase in yield with the addition of only nitrogen.

The lake data indicate phosphorus limitation in August as well (the mean inorganic nitrogen/orthophosphorus ratio was 16/1); however, the mean N/P ratio in October was 9/1, and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in $kg/km^2/year$, at station C-1 of nearby Witmer Lake** and multiplying by the ZZ area in km^2.

The operator of the Whetzel High School wastewater treatment plant did not participate in the Survey, and nutrient loads were estimated at 0.567 kg P and 3.401 kg N/capita/year (note that the per-capita estimate for phosphorus was reduced by 50% to adjust for the Indiana phosphate-detergent ban instituted in January, 1972).

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* See Working Paper No. 175.
** See Working Paper No. 349.

A. Waste Sources:

1. Known domestic -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Whetzel High School	500	?	189.2*	Dallas Lake

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Westler Lake outlet	1,400	80.5
b. Minor tributaries & immediate drainage (non-point load) -	25	1.4
c. Known domestic STP's -		
Whetzel High School	285	16.4
d. Septic tanks** -	10	0.6
e. Known industrial - None	-	-
f. Direct precipitation*** -	20	1.1
Total	1,740	100.0

2. Outputs -

Dallas Lake outlet 1,630

3. Net annual P accumulation - 110 kg.

* Estimated at 0.3785 m^3/capita/day.
** Estimate based on 60 lakeshore dwellings; see Working Paper No. 175.
*** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Westler Lake outlet	66,630	92.8
b. Minor tributaries & immediate drainage (non-point load) -	1,560	2.2
c. Known domestic STP's -		
Whetzel High School	1,700	2.4
d. Septic tanks* -	640	0.9
e. Known industrial - None	-	-
f. Direct precipitation** -	1,230	1.7
Total	71,760	100.0

2. Outputs -

Dallas Lake outlet 48,390

3. Net annual N accumulation - 23,370 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Westler Lake outlet	14	681

* Estimate based on 60 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.53	0.10	62.9	20.5

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Dallas Lake:	
"Dangerous" (eutrophic loading)	0.98
"Permissible" (oligotrophic loading)	0.49

V. LITERATURE REVIEWED

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Div. Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATAWACT LAKE	0.055	1.660	466.667	10.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.008
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.823	6.947	15.000	0.007
1829	MONSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	384.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLEY LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	480.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CHOURED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.018	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.445	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SDD-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NU
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	94 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITMER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATAHACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1845 DALLAS LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 103.1

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1845A1	103.1	1.27	1.49	2.89	1.96	1.27	0.96	0.59	0.22	0.20	0.22	0.51	0.92	0.97
1845B1	97.9	1.21	1.41	1.99	1.87	1.21	0.91	0.56	0.21	0.19	0.21	0.48	0.87	0.92
1845Z2	4.1	0.045	0.059	0.088	0.079	0.051	0.040	0.023	0.006	0.007	0.007	0.020	0.040	0.039

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 103.1
SUM OF SUB-DRAINAGE AREAS = 102.0
TOTAL FLOW IN = 11.58
TOTAL FLOW OUT = 11.70

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1845A1	6	73	1.614	9	2.379				
	7	73	1.104	14	1.133				
	8	73	0.793	12	0.765				
	9	73	0.566	8	0.595				
	10	73	0.510	6	0.510				
	11	73	0.510	9	0.453				
	12	73	0.963	8	0.708				
	1	74	1.614	9	0.934				
	2	74	2.010	9	2.237	23	2.379		
	3	74	2.435	9	3.115	23	2.180		
	4	74	1.756	13	2.010				
	5	74	1.586	11	1.331				
1845B1	6	73	1.529	9	2.265				
	7	73	1.048	14	1.076				
	8	73	0.765	12	0.736				
	9	73	0.538	8	0.566				
	10	73	0.481	6	0.481				
	11	73	0.481	9	0.425				
	12	73	0.906	8	0.680				
	1	74	1.529	22	2.039				
	2	74	1.897	9	2.124	23	2.265		
	3	74	2.322	9	2.945	23	2.067		
	4	74	1.671	13	1.897				
	5	74	1.501	11	1.274				
1845Z2	6	73	0.065	9	0.096				
	7	73	0.044	14	0.046				
	8	73	0.032	12	0.031				
	9	73	0.023	8	0.029				
	10	73	0.020	6	0.020				
	11	73	0.020	9	0.018				
	12	73	0.038	8	0.029				
	1	74	0.065	9	0.039	22	0.086		
	2	74	0.080	9	0.090	23	0.096		
	3	74	0.098	9	0.125	23	0.087		
	4	74	0.071	13	0.080				
	5	74	0.063	11	0.054				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

184501
41 32 53.0 085 25 00.0 3
DALLAS LAKE
18087 INDIANA

11EPALES 2111202
0097 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/04	09 45	0000	12.4		108	485	8.40	198	0.040	0.700	0.790	0.003
	09 45	0006	12.4	10.0		490	8.40	198	0.040	0.700	0.790	0.005
	09 45	0015	12.3	10.0		490	8.20	197	0.040	0.700	0.790	0.006
	09 45	0025	12.3	9.1		490	8.00	196	0.040	0.700	0.770	0.006
	09 45	0035	9.0	8.3		490	7.80	197	0.030	0.700	0.990	0.013
	09 45	0050	8.6	8.1		490	7.70	196	0.030	0.700	1.010	0.017
	09 45	0065	8.2	6.7		490	7.60	196	0.030	0.700	0.870	0.023
	09 45	0080	8.1	4.4		490	7.50	196	0.080	1.000	1.040	0.061
	09 45	0093	8.0	3.4		520	7.40	199	0.240	1.100	0.900	0.103
73/08/03	15 50	0000	25.4		70	450	8.40	182	0.110	1.400	0.060	0.014
	15 50	0005	25.0	8.0		440	8.50	180	0.060	0.800	0.060	0.008
	15 50	0010	24.4			437						
	15 50	0015	22.7	5.5		438	8.00	187	0.080	0.900	0.170	0.007
	15 50	0020	15.6	0.1		395	7.50	199	0.240	1.100	0.470	0.014
	15 50	0030	11.5	0.1		354	7.50	200	0.220	0.800	0.580	0.007
	15 50	0040	10.0			339						
	15 50	0050	8.5			327						
	15 50	0060	8.1	0.1		325	7.40	195	0.170	0.900	1.000	0.062
	15 50	0070	8.1			324						
	15 50	0080	8.0			324						
	15 50	0085	7.9	0.2		327	7.40	201	0.640	1.700	0.220	0.132
73/10/12	14 45	0000	19.0	8.4	84	392	8.50	178	0.050	0.700	0.020	0.022
	14 45	0010	18.6	8.2		391	8.40	179	0.030	0.700	0.020	0.012
	14 45	0018	18.1	7.0		390	8.30	179	0.040	0.700	0.020	0.020
	14 45	0025	13.9	0.0		390	7.60	202	0.410	1.000	0.040	0.018
	14 45	0035	9.3	0.0		351	7.50	200	0.460	1.100	0.030	0.015
	14 45	0050	7.2	0.2		331	7.40	198	0.330	1.000	0.330	0.019
	14 45	0065	6.6	0.0		327	7.40	200	0.820	1.700	0.040	0.147
	14 45	0080	6.3	0.0		333	7.30	212	1.810	3.300	0.030	0.293
	14 45	0094	6.3	0.0		336	7.30	216	2.610	3.100	0.040	0.324

STORET RETRIEVAL DATE 76/03/30

184501
41 32 53.0 085 25 00.0 3
DALLAS LAKE
18087 INDIANA

11EPALES 2111202
0097 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/04	09 45	0000	0.026	11.9
	09 45	0006	0.035	
	09 45	0015	0.035	
	09 45	0025	0.036	
	09 45	0035	0.040	
	09 45	0050	0.044	
	09 45	0065	0.054	
	09 45	0080	0.087	
	09 45	0093	0.142	
73/08/03	15 50	0000	0.018	13.2
	15 50	0005	0.022	
	15 50	0015	0.023	
	15 50	0020	0.022	
	15 50	0030	0.020	
	15 50	0060	0.074	
	15 50	0085	0.180	
73/10/12	14 45	0000	0.022	5.8
	14 45	0010	0.017	
	14 45	0018	0.023	
	14 45	0025	0.024	
	14 45	0035	0.022	
	14 45	0050	0.024	
	14 45	0065	0.146	
	14 45	0080	0.291	
	14 45	0094	0.360	

STORET RETRIEVAL DATE 76/03/30

184502
41 32 57.0 085 25 34.0 3
DALLAS LAKE
18087 INDIANA

11EPALES 2111202
0074 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/04	10 35	0000	12.2		96	490	8.50	199	0.040	0.900	0.810	0.003
	10 35	0006	12.1	10.1		480	8.50	198	0.030	0.600	0.800	0.002
	10 35	0015	11.9	10.1		460	8.40	197	0.030	0.600	0.810	0.004
	10 35	0022	11.8	9.9		450	8.30	197	0.030	0.600	0.810	0.008
	10 35	0032	10.5	9.2		490	8.10	195	0.030	0.600	0.880	0.006
	10 35	0040	8.9	7.4		490	8.00	195	0.040	0.500	1.000	0.017
	10 35	0055	8.6	6.1		490	8.00	196	0.030	0.500	0.980	0.005
	10 35	0070	8.5	6.2		495	8.10	195	0.110	0.600	0.950	0.052
73/08/03	16 50	0000	25.8		60	450	8.50	177	0.070	0.900	0.060	0.005
	16 50	0005	24.5	8.5		437	8.50	177	0.080	0.800	0.060	0.006
	16 50	0010	24.4			439						
	16 50	0015	23.6	6.0		440	8.20	185	0.090	0.900	0.170	0.008
	16 50	0020	14.5	0.1		395	7.50	201	0.240	1.100	0.540	0.012
	16 50	0025	12.6			366						
	16 50	0030	11.6			358						
	16 50	0040	10.1	0.0		342	7.40	200	0.360	1.300	0.500	0.040
	16 50	0050	8.7			343						
	16 50	0060	8.6			340						
	16 50	0065	8.5			343						
	16 50	0068	8.5	0.0		340	7.30	240	1.440	2.000	0.130	0.181
73/10/12	15 35	0000	19.4	8.8	102	395	8.50	178	0.050	1.200	0.020	0.012
	15 35	0014	19.0	8.2		394	8.40	177	0.050	0.700	0.010	0.010
	15 35	0020	16.2	0.8		391	7.70	187	0.050	1.100	0.020	0.026
	15 35	0030	10.4	0.0		362	7.50	200	0.520	1.200	0.050	0.019
	15 35	0040	8.6	0.0		346	7.50	200	0.730	1.500	0.050	0.021
	15 35	0055	7.4	0.0		343	7.40	205	1.860	2.800	0.060	0.205
	15 35	0069	7.1	0.0		346	7.30	220	2.480	3.400	0.060	0.267

STORET RETRIEVAL DATE 76/03/30

184502
41 32 57.0 085 25 34.0 3
DALLAS LAKE
18087 INDIANA

11EPALES 2111202
0074 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/04	10 35	0000	0.023	12.9
	10 35	0006	0.030	
	10 35	0015	0.028	
	10 35	0022	0.026	
	10 35	0032	0.027	
	10 35	0040	0.037	
	10 35	0055	0.061	
	10 35	0070	0.082	
73/08/03	16 50	0000	0.014	8.3
	16 50	0005	0.016	
	16 50	0015	0.023	
	16 50	0020	0.027	
	16 50	0040	0.070	
	16 50	0068	0.282	
73/10/12	15 35	0000	0.036	8.3
	15 35	0014	0.021	
	15 35	0020	0.035	
	15 35	0030	0.028	
	15 35	0040	0.029	
	15 35	0055	0.207	
	15 35	0069	0.270	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/03/30

1845A1
41 33 24.0 085 25 27.0 4
DALLAS LK-HACKENBURG LK CONNECTI
18 7.5 OLIVER LAKE
O/DALLAS LAKE
NW END OF LAKE APPROACH BY BOAT
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/14	11 30		0.010K	1.100	0.046	0.005K	0.010
73/08/12	13 00		0.010K	0.960	0.019	0.010	0.015
73/09/08	10 05		0.010K	0.690	0.014	0.005K	0.010
73/10/06			0.010K	0.970	0.017	0.005K	0.020
73/11/09	13 03		0.012	0.900	0.056	0.005K	0.020
73/12/08	09 00		0.028	1.900	0.184	0.016	0.140
74/02/09	11 30		0.420	1.000	0.160	0.005	0.045
74/02/23	11 15		0.750	0.800	0.130	0.015	0.030
74/03/09	12 00		0.750	1.800	0.085	0.025	0.135
74/03/23	12 00		1.000	1.000	0.010	0.005	0.055
74/04/13	10 15		0.910	1.200	0.025	0.010	0.035
74/05/11	15 45		0.860	1.500	0.120	0.025	0.120

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

184581
41 32 45.0 085 24 44.0 4
DALLAS LK-WRESTLER LK CONNECTION
18 7.5 OLIVER LAKE
I/DALLAS LAKE
BANK SAMPLE TAKE FROM E BANK
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13 05		0.390	1.600	0.016	0.005K	0.030
73/07/14	10 15		0.014	1.760	0.065	0.005	0.015
73/08/12	13 25		0.010K	1.000	0.026	0.010	0.015
73/09/08	09 30		0.010K	0.690	0.013	0.005K	0.010
73/10/06			0.010K	1.260	0.020	0.005K	0.020
73/11/09	12 00		0.040	1.950	0.520	0.036	0.045
73/12/08	09 00		0.076	1.300	0.276	0.008	0.075
74/01/22			0.300	1.200	0.240	0.010	0.055
74/02/09	11 00		1.200	1.000	0.185	0.010	0.050
74/02/23	10 00		1.600	3.400	0.240	0.020	0.050
74/03/09	12 45		1.520	2.150	0.150	0.020	0.090
74/03/23	11 00		1.340	2.000	0.075	0.020	0.070
74/04/13	09 30		1.120	2.900	0.115	0.015	0.030
74/05/11	15 10		0.880	1.000	0.200	0.055	0.115

K VALUE KNOWN TO BE
LESS THAN INDICATED